Before the

FEDERAL COMMUNICATIONS COMMISSION

Washington, DC 20054

In the Matter of	)	
	)	
International Comparison and Consumer Survey Requirements in the Broadband Data Improvement Act	)	GN Docket No. 09-47
	)	
A National Broadband Plan for Our Future	)	GN Docket No. 09-51
	)	
Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion and Possible Steps to Accelerate Such Deployment Pursuant to Section 706 of the Telecommunications Act	)	GN Docket No. 09-137

To: The Commission

COMMENTS – NBP PUBLIC NOTICE #2 –
AMERICAN ELECTRIC POWER COMPANY, INC

American Electric Power Company, Inc. ("AEP") is one of the largest energy providers in the United States. With almost 38,000 Megawatts of generating capacity, AEP serves more than 5.2 million customers. AEP serves parts of 11 states, covering more than 197,000 square miles of service territory and operates approximately 38,000 miles of transmission lines and more than 212,000 miles of distribution lines.

Throughout its 100-year-plus history, AEP has been a leading innovator in the electric utility industry. From deploying TranstexT, one of the earliest Demand Response technologies in the late 1980s, through actively participating in the development of electric industry automation protocols, to testing and deploying some of the latest Home

Area Network (HAN) technology, AEP has a rich history in the Smart Grid applications space. Similarly, AEP has been using a wide variety of wireless technologies in the operation of its business since the 1920s, which puts the company in a position to be well-qualified to provide comment on use of wireless technology in the Smart Grid.

AEP appreciates the opportunity to provide comment to the Commission on the implementation of Smart Grid technology and how it relates to broadband deployment in the U.S. These comments are intended to reflect AEP's experiences in this area and should not be construed as a complete view of the electric utility industry as a whole. Furthermore, given the amount of time made available by NBP Public Notice #2 for preparing comments in this proceeding and the level of detail requested by the Commission, it was not possible to fully answer all of the questions posed. Additionally, much of the detailed analyses that the Commission invited commenting parties to include in their submissions would involve data that AEP considers proprietary due to the non-disclosure agreements it maintains with its equipment and service provider partners. AEP would prefer for those partners to supply the technical and cost data directly to the FCC, as they are in the best position to submit the most accurate and up-to-date information about the equipment and services that they provide.

The view of what actually constitutes Smart Grid technology can vary from one utility to the next. In general, AEP considers Smart Grid technology that which allows the utility to meet the operational challenges of its business in a cost effective and environmentally sound manner. Some of the technologies that fall into this category, like substation Supervisory Control and Data Acquisition (SCADA), are not new but

AEP believes including them in a comprehensive approach to modernizing the electric system is what truly defines the Smart Grid.

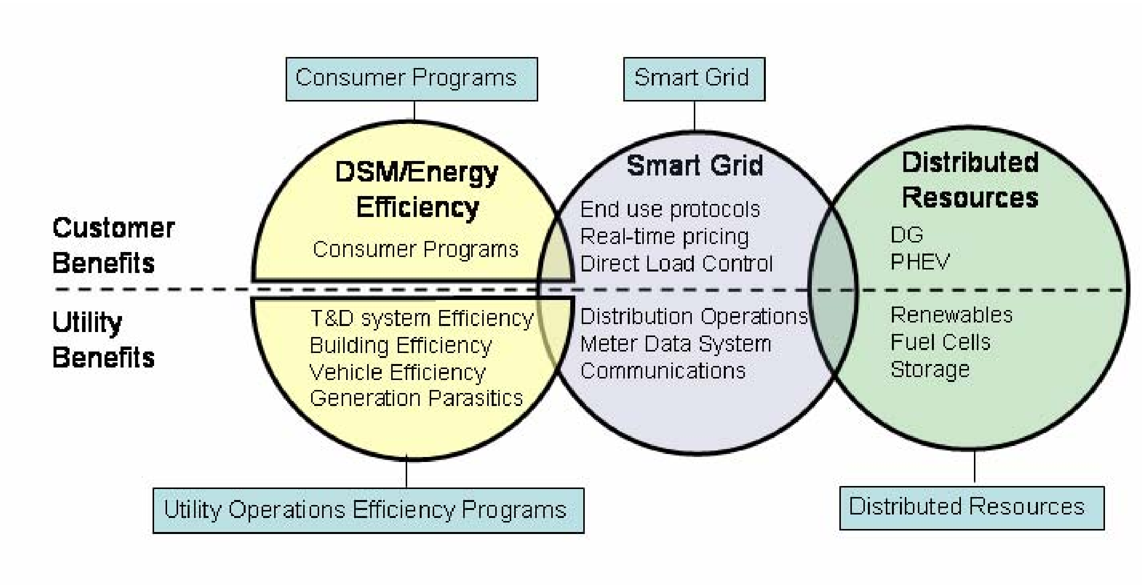

Figure 1 – AEP's view of the role of Smart Grid technology

1.0 Communication Technology Drivers

Before discussing which communications technologies are suitable for Smart Grid applications, it is important to understand the underlying dimensions that play into the consideration of one technology over the other. The most commonly considered technical parameters are:

Bandwidth: The business challenge being solved will drive the requirement of how much data needs to be transmitted and in what time frame. Business needs for bandwidth are extremely variable. Some applications may transmit hundreds of bytes per day and others may require megabits per second. These requirements will also change over time as the business needs and capabilities of the underlying technology evolve. A communications solution that is suitable today may be outgrown tomorrow.

Security: Smart Grid applications that touch critical points of the electric infrastructure may require extraordinary measures to protect them from malicious actions whereas those which increase the utility's operational efficiency but have no direct connection to the electric grid may have a lesser requirement. However, in all cases some level of security is required to insure personal information is kept confidential and the operation of electric infrastructure is uninterrupted.

Availability: Electric utilities must offer ubiquitous service in the most rugged and remote areas of the U.S. which are often bypassed by many telecommunications service providers. AEP often finds it necessary to deploy multiple solutions to a business challenge simply because no one communications technology is viable everywhere the company operates.

Reliability: The reliability required of a particular solution depends on the business need it is serving. Some applications that gather operational data for historical records and long term trending can often tolerate intermittent outages whereas some mission-critical applications that affect the safe, reliable operation of the grid cannot.

Cost: Utilities are held accountable by public utility commissions, shareholders, and other concerned parties to provide reliable service in the most cost effective manner possible. This means the optimal mix of the other parameters listed (bandwidth, security, etc.) must be selected in order to achieve this cost effectiveness. Furthermore, all of the proper costs of a given solution must be identified in an analysis to be sure the total cost of ownership is evaluated.

1.1 Suitability of Communication Technologies

As noted by the Commission in the NPB Public Notice #2, the electric utility industry is using a variety of communications technology to implement Smart Grid programs, and AEP is no exception. There is a broad spectrum of Smart Grid applications and each is driven by business requirements that vary by utility. These business requirements are determined in concert with the state public utility commissions that regulate the electric utility industry, resulting in different levels of technology adoption. This of course means telecommunication network requirements vary widely, even for the same class of application. For example, some states may offer utilities cost recovery for extensive AMI programs that encourage energy efficiency and cost savings by use of sophisticated home energy networks. Other states, however, may take a much more reserved approach and limit meter programs to simpler time-of-use and demand response that require only limited telecommunications capability in order to operate.

Besides varying business requirements, different architectural approaches to the same problem can result in different communication requirements. A peer-to-peer automatic feeder restoration system, which distributes the operational logic across several switch controls, may transmit more data and require lower latencies needs than a restoration system that centralizes the logic in a central control unit. Similarly, for many Smart Grid applications there often are varying degrees of functionality. Often a utility may opt for a minimal set of features in cases when the available communication technologies are limited in capability, but will implement a richer feature set when more advanced communication technology is available.

Not only do current network requirements vary widely, Smart Grid applications will continue to evolve and new ones will emerge. This, in turn, will increase the demands placed upon the communications networks that support the Smart Grid. For example, while automated meter infrastructure applications are seen today as relatively low-bandwidth in nature, future real-time pricing schemes may be very aggressive, requiring significantly more bandwidth. For this reason, it is important to not constrain future applications by making short-sighted assumptions about network requirements based on today's technology and architectures.

While specifying the exact requirements for Smart Grid applications can be difficult, some comparisons between applications can be made in a generalized manner. Table 1.1 shows a number of sample applications and illustrates their relative needs for latency, bandwidth, reliability, and coverage.

1.2 Communications Technology to Meet Smart Grid Requirements

Since network requirements vary widely by application and regulatory jurisdiction, it follows naturally that a variety of technologies are used to meet those needs. "Last mile" technologies tend to be wireless in nature, since the large scale and complexity of the electric distribution system makes constructing a wireline telecommunications overlay network impractical from a cost perspective. Furthermore, applications designed to detect downed wires and poles, such as automatic feeder restoration and outage detection, will not operate properly if they rely on telecommunications wireline infrastructure that is damaged at the same time the electric infrastructure is disrupted. Substation and backhaul network connections for Smart Grid applications see more use of broadband networks, including fiber optic and other wireline circuits, since these connections are more practical and cost effective in these applications.

	Smart Grid Application		Latency	Bandwidth	Reliability	Coverage
Current	Automated Meter Infrastructure	Meter Reading	◑	◔	◔	●
Current	Automated Meter Infrastructure	Direct Load Control	◕	◔	◕	●
Current	Automated Meter Infrastructure	Real Time Pricing	◕	◕	◕	●
Current	Automatic Feeder Restoration		◔	◑	◕	●
Current	Volt – VAr Control		◕	◑	●	●
Current	Substation Supervisory Control and Data Acquisition		◔	◔	●	●
Current	Line Device Supervisory Control and Data Acquisition		◔	◔	◕	●
Future	Distributed Generation Control		◑	◑	◕	●
Future	Advanced Distribution Line Protection		●	◕	●	●
Future	Plug-in Hybrid Electric Vehicles		◕	◕	◑	●
Less Stringent ← ○ ◔ ◑ ◕ ● → More Stringent						

Table 1.1 – Nominal Requirements for Smart Grid Communication Networks

Like the rest of the electric utility industry, AEP uses a variety of privately-operated and commercially available network technologies to meet its Smart Grid communications requirements. The Company believes that no one technology can meet all of its needs and, in fact, the use of a variety of communications tools provides for an optimal mix of redundancy and cost effectiveness.

Application \ Technology	Commercial Wireless	Point-to-Multipoint Radio	Unlicensed Mesh	Point-to-point microwave	Private Fiber	Leased Wireline Facilities	Land Mobile Radio	VSAT	Customer-Provided Internet
Advanced Meter Infrastructure (Last Mile)	●	○	●						◓
Advanced Meter Infrastructure (Backhaul)	●	◓	○	◓	◓	○	○	○	
Automatic Feeder Restoration	○	●	●				○		
Volt-VAr Management		○	◒				○		
Substation SCADA	◑	●		●	●	●	◑	◑	
Distribution Device SCADA (Last Mile)	●	●	●				◑		
Home Area Network	○	○	◑						◓
Legend:	**● – In use today** **◑ – Limited use today** **◒ – In testing/development** **◓ – Likey use in future** **○ – Possible use in future**								

Table 1.2 – Communications used for Smart Grid deployment at AEP

While privately operated facilities give the Company a great deal of control over reliability and availability, they are often complimented by facilities obtained from public carriers that enjoy economies of scale that utilities cannot achieve on their own. Table 1.2 summarizes the use of communication technologies in use at AEP for Smart Grid deployments. Each technology is described in further detail below.

1.2.1 Commercial Wireless (Cellular)

AEP has used commercial wireless services for a wide variety of applications for well over a decade. The first large scale application of cellular technology at AEP was for remotely downloading datasets from commercial and industrial ("C&I") meters and power quality monitoring devices. Today, commercial wireless technology can be found playing many roles across the AEP system, from monitoring underground network protectors to providing backhaul for AMR/AMI collectors. Cellular data services have proven to be a dependable, cost-effective means for gathering routine operational data, especially in locations where obtaining wireline facilities proves to be impracticable. The major drawback to commercial wireless services is that coverage tends to be available mostly around metropolitan areas and highway corridors, but a large portion of AEP's service territory is in rural areas and many facilities lack adequate coverage.

1.2.2 Point-to-Multipoint Wireless

AEP utilizes privately-operated point-to-multipoint networks, operating mostly in the licensed 900 MHz Multiple Address System (MAS) and unlicensed 902-928 MHz Industrial, Scientific, and Medical (ISM) bands, for backhaul of SCADA connections and some distribution automation. This technology is usually limited to locations that have line-of-sight to an existing AEP telecommunications tower, but when available, proves to be very reliable and cost effective. The biggest issue with the technology currently in use tends to be the limited throughput available, so AEP is starting to look to solutions in higher frequency bands (such as 3.65 GHz WiMAX) to meet an ever-increasing need for bandwidth, especially at the substation. However, higher-speed point-to-multipoint technologies are limited by the physical reality that increased throughput requires a combination of more spectrum, higher power, and/or higher to signal-to-noise ratio; with the spectrum and devices currently available to utilities, these factors conspire to reduce the effective distance of a point-to-multipoint base station. This in turn, drives up the deployment costs and makes it difficult to deploy high-speed unlicensed point-to-multipoint networks in rural areas. Dedicated spectrum (i.e.with a low noise floor) and the ability to operate at power levels higher than those available with Part 15 or 3.65 GHz bands would allow AEP to build higher speed networks with better coverage.

1.2.3 Unlicensed Mesh

AEP has utilized 900 MHz mesh network technology for several years for peer-to-peer feeder automation systems. This technology has been resilient and a cost-effective solution in certain areas of the country where obtaining long line-of-sight paths to all automation end points is challenging at best. AEP has recently started piloting AMI systems that also utilize 900 MHz mesh network technology. While initial success with mesh systems in a license-free environment has been promising, AEP is concerned that future demands on the 902 – 928 MHz spectrum will raise the noise floor in some areas to the point where metro-area mesh networks will no longer be viable.

1.2.4 Private Point-to-Point Microwave

Point-to-point microwave technology has been a mainstay of utility networks, including that of AEP, for over fifty years. As the technology has improved, so has throughput and reliability. This technology is well-understood, extremely reliable, and can provide the communication backbone for practically any Smart Grid application. It is ideally suited for certain station-to-station applications such as protective relaying and backbone communication. So while it will not play a role in extending smart grid application closer to the customer, AEP believes that private point-to-point microwave will continue to provide a solid foundation for large-scale utility wide area networks.

1.2.5 Private Fiber

AEP uses privately owned fiber optic facilities for long-haul as well as metro-area communications. Often used with point-to-point microwave radio in a complementary fashion, fiber optic networking technology also forms the underlying foundation for Smart Grid applications, tying communications between devices in the field with the back-office systems that enable the Smart Grid application. These networks interconnect major facilities across the AEP System. Unfortunately, while fiber allows for an incredible amount of capacity, especially in comparison with other technologies, its high cost to deploy makes it impractical for wide-spread deployment in the electric distribution system.

1.2.6 Leased wireline facilities

In many instances, AEP has found it cost effective to use leased circuits to provide backhaul connectivity to remote locations, especially those outside the core coverage area of AEP's private communications network. These leased facilities include traditional telephone company circuits (56 kbps, DS1) as well as partnerships with local cable television providers and facility-based CLECs. Like point-to-point microwave and fiber optic networks, leased wireline facilities are too expensive to utilize beyond the backhaul network.

1.2.7 Land Mobile Radio

While AEP's Land Mobile Radio (LMR) system is primarily a work management resource, a limited amount of low-data rate Smart Grid applications have been supported by that network. Status monitoring of reclosers and critical distribution transformers over AEP's 800 MHz LMR network is possible where poor or no commercial wireless overage exists. Such use is limited however, since the 25 kHz channels used for 800 MHz LMR networks have relatively low data capacity.

1.2.8 Satellite Communications

AEP uses VSAT-type satellite communications in a limited number of Distribution SCADA applications, mainly in locations where no other communication options exist. While fairly reliable, VSAT communication is subject to rain fade, which is only tolerable for the monitoring and control of less-critical locations of the electric grid.

1.3 Adequacy of Commercial Networks for Smart Grid Networks

In general, commercial networks can meet electric utility needs in many situations, but the specifics of an application need to be analyzed to see which solution(s) are the most technically appropriate and cost effective for a given situation. There is no simple "yes/no" answer to whether or not a commercially-available network is adequate for utility needs; the answer depends on the application context. AEP evaluates candidate technologies on both a cost basis and a risk basis with a desire to find an optimal mix of low cost and an appropriate level of reliability. For example, commercial wireless is used in many asset management applications because it allows AEP to gather a large amount of non-real-time operational data for a moderate cost. The cost is much lower than what AEP can develop an in-house network connection for,due to the economies of scale commercial wireless operators can achieve in both geography and end-user equipment. Since the data gathered is not time-critical, temporary outages are acceptable since they do not affect the equipment's ability to carry on with the delivery of energy. On the other hand, AEP also tends to build private backbone networks on fiber and microwave transport because it can do so in a cost-competitive manner with high reliability. Critical applications are often placed on private facilities when the risk of failure must be mitigated.

1.3.1. Reliability

To be clear, it is not that a failure is never expected to take place in private networks; however failures need to be infrequent and quickly remedied when they do occur. When AEP chooses a privately-owned network approach, often it is because local commercial facilities are not reliable and the local service provider is incapable of making repairs in a timely manner. Quite often, the restoration schedule of a commercial carrier does not align with the critical needs of an electrical utility, and those commercial facilities that may not be restored quickly in the face of a wide-scale outage (as in the case of a natural disaster like an ice storm or hurricane) are not used to communicate with critical devices in the electric grid. AEP retains a well-trained technical work force to immediately repair telecommunication outages that effect important parts of the electric grid.

While AEP does not have a large number of critical grid devices that use commercial wireless data services, experience with commercial wireless for work force management (i.e. mobile data computing) in disaster situations continues to prove that commercial carriers have much room for improvement before they will be ready to provide critical data services. When the remnants of Hurricane Ike struck Ohio in September of 2009, the worst disaster (in terms of customer outages) ever experienced by AEP Ohio, congestion in the commercial providers' networks rendered them nearly useless in large parts of the Columbus metropolitan area. In order to operate critical grid components on commercial wireless networks, providers will need to give priority to data traffic sent and received by critical infrastructure devices, since losing contact with such devices for several days (which would have certainly occurred in Ohio during the fore mentioned incident) is simply unacceptable.

1.3.2 Availability

While availability is addressed in another section of these comments, availability does play a part in the determination as to whether or not a commercial technology is suitable for a given application. While many broadband technologies may be available in metropolitan areas across the US, the fact remains that many of these technologies are not suitable for utility applications in rural areas because they simply are not available. AEP operates primarily in rural areas of the US and needs solutions that cover large regions of its service territory in order to find them adequate for utility service.

1.3.3 Cost

While AEP applauds the strides commercial wireless carriers have made in pricing bulk data plans for individual data devices, the Company has found (through a number of requests for proposals) that pricing for last-mile AMI deployment is still too high to compete with privately-owned alternatives. While AMI is not a particularly data-intensive application, the pricing that commercial carriers provide for wide-scale AMI indicates that an extremely large number of very small-throughput devices still represents a significant burden on their networks. AEP believes that the FCC should encourage wireless commercial carriers to utilize technology that would allow them to serve a large number of "incidental" devices with very modest throughput needs at a very low price.

Likewise as previously mentioned, commercial wireline networks are not cost effective in deployments of hundreds of thousands or millions of nodes. Quite often, copper-based facilities are not even suitable for electric utility backbone locations due to the high cost of isolation devices which are used to prevent ground potential rise at high voltage facilities from causing safety or equipment reliability issues in the service provider's network.

2.1 Availability of Communications Networks

As noted by the Commission in the NBP Public Notice #2, electric utilities offer near universal electric service, including in many geographies where no existing suitable communication networks currently exist, and that situation holds very true for AEP and its 197,500 square miles of service territory in Michigan, Indiana, Ohio, Kentucky, West Virginia, Virginia, Tennessee, Oklahoma, Louisiana, Arkansas, and Texas, much of it rural in nature. AEP's service territory also represents all types of geographic terrain. The challenges for providing communications to these diverse remote areas that are sparsely populated can be very challenging from both a commercial provider and a private entity perspective when considering the business and technical issues.

From a public carrier perspective, the rural areas that are not populated do not provide for a good return on investment for their enterprise, so there is no business case for the commercial providers to provide ubiquitous commercial wireless services in these areas. While the carriers may meet the Commission's build-out requirements, often this is not enough to cover all of the electric customers and infrastructure in a given rural area. And while a number of factors are considered when evaluating commercial wireless service against other options, the service must be available before it can be considered at all. Therefore, it goes that coverage is the first thing that must be evaluated when considering a commercial service. AEP has found coverage to be a major issue when considering commercial services for its rural service territory.

As for the actual coverage statistics for these rural areas, the commercial wireless carriers themselves would be best suited to provide the FCC with detailed coverage maps and services offerings throughout the United States. However, as an example for the Commission's consideration, AEP has performed a GIS-based analysis[†] whereby it was determined that approximately 59% of the AEP substations were located outside the 3G coverage footprints of commercial wireless carriers. It as also determined that approximately 20% of the AEP substations were located outside the 2G coverage footprints of the same carriers. While this cannot directly be applied to all of the key control infrastructure and potential Smart Grid communications nodes, it does reveal that much of AEP service territory is not within commercial coverage for these important connection points.

[†] AEP has obtained 2G and 3G wireless coverage data from commercial wireless service providers (under non-disclosure agreements) and overlaid it onto a map of AEP substations locations to determine the percentage of those substations that are not within the existing coverage of those commercial carriers.

AEP would like to note that is does recognize the challenges that public telecommunications carriers face in rural areas. The coverage by AEP existing internal private telecommunications backbone (i.e. company-owned fiber and microwave facilities) to these same substations and critical key control locations is even sparser than that of the wireless carriers' 3G service offerings. AEP estimates that 90 % of the locations are out of reach of its existing internal private communication backbone that would be able to support bandwidth requirements for Smart Grid communications. However, given the right circumstances, it is possible to provide some level of service to large portions of these areas, as AEP does own and operate an internal Land Mobile Radio LMR 800 MHz trunked radio system that provides coverage to approximately 95% of the AEP service territory. Unfortunately, this LMR system operates on non-continuous 25 kHz channels and will not support significant amounts of data and is presently close to its limit in supporting voice dispatch, mobile data, Automati Vehicle Location (AVL), and low data-rate station alarm reporting.

2.2 What constitutes suitable communications networks?

When evaluating communication network options for different types of control infrastructure AEP considers all of the following:

- Coverage/Availability – AEP's 197,000 square miles of service territory
- Bandwidth – Is it able to carry the data today and the foreseeable growth?
- Latency – Is the response time acceptable?
- Dependable/Reliable – Is the system or service available when you need it?
- Affordable – Is the solution or service cost effective?
- Secure – Does the system or service provide the necessary security?

These considerations are factored into the decision process to varying degrees depending on the communication needs to be met. Obviously, the requirements for

SCADA backhaul are different than the need for last mile AMI communications. For example, ignoring cost, the communication requirements for a modest Advanced Meter Infrastructure (AMI) application might be successfully met by unlicensed RF Mesh, commercial 2G, commercial 3G, or private broadband wireless (WiMAX or LTE). However, if requirements include Real Time Pricing (RTP) or passing large amounts of data between the HAN and the utility, then the more stringent requirements for that data could eliminate the unlicensed RF mesh and 2G options from consideration.

Another example to consider is advanced feeder automation and line protection. When considering the communication requirements for these two functions it is critical that the latency of the associated communications be low and the reliability of the systems be very high. In this case, most commercial options (2G, 3G, commercial broadband or VSAT) do not offer the availability, reliability, or latency requirements demanded for these two functions. A suitable solution for this example could be a privately-owned low latency telecommunications technololgy such as a fiber optic, point –to-point microwave, or point-to-multipoint wireless network. In a small number of cases, a commercial wireline solution with the appropriate service level agreements (SLAs) to guarantee bandwidth and reliability may also be suitable, but these SLAs often come at a high cost if they are available at all.

In all situations of considering communication options for Smart Grid applications, security plays a major role in what communication solutions may be deployed. Even if a solution meets the latency, bandwidth and cost profile for an application, it will not be used unless it meets at least a minimum level of security; and some public carrier solutions may be eliminated if the specific application carries an especially high risk of security being breeched.

2.3 Impediments to the Use of Commercial Network Options

In many cases, even when available to AEP, commercial network options are not utilized for Smart Grid communications. This is because when evaluated, the risks due to reliability, availability, and cost cannot be satisfactorily mitigated. In most Distribution Automation (DA) or SCADA applications, commercial wireless networks are generally not utilized due to the reliability and availability issues with these solutions. Many of the carriers do not provide generator back up to their base station sites, so the sites are not available when utilities need them the most. When sufficient backup power is available, DA and SCADA would compete with other users on the commercial system. It is AEP's experience that during wide-scale emergency events, man made or natural, commercial systems are flooded with traffic and largely become unusable. Utilities would need priority access on commercial systems in order to use them for critical communication needs such as DA and SCADA communications.

Additionally, AEP has found that the cost of using commercial wireless for wide-scale deployments is not cost-effective when compared to other options. AEP has included public wireless options in several Requests for Proposals (RFP) issued to the AMI vendor community to identify the best option for the AMI connectivity. So far, the option of commercial wireless-connected meters has been eliminated. When compared to RF mesh solutions included in the various RFP responses, the public carrier options were much less cost effective. AEP is optimistic, however, that the continuing evolution of public wireless tehnology and pricing models will push that option to be much more competitive with competing private options.

2.4 The Effect of Availability on Smart Grid Deployment Costs

AEP has significant experience in deploying SCADA and DA communications over its service territory. AEP has learned that just because a suitable broadband network or service is available in a geographic area does not necessarily mean that network service will be cost effective for deployment. Public network options (wireline and wireless) are considered every time AEP installs a new SCADA circuit to a new or existing substation. If one or more are available, a "build –vs. - buy" analysis is performed to determine the total cost of ownership for the available public and private options. In many cases a commercial solution is the most cost effective, but often such is not the case. AEP finds the situation counter-intuitive; one would think it should be more cost effective for AEP to leverage a commercial service that is also supporting other application and customers, spreading the cost over a larger base of users.

Likewise and as noted above, the same situation has emerged for last-mile AMI deployments. While commercial wireless has proven to be very cost effective for AMI backhaul (i.e. conneting mesh collector equipment to the back office), it has proven to be the more costly "under-the-glass" option for communicating with the meter and, at least for AEP's initial pilots, was dropped from consideration. It is interesting to note that when comparing commercial wireless for AMI backhaul solutions with those for direct-to-the-meter solutions, the nature of data transmitted does not change much, only the number of end points is changing. Because of this pricing anomaly, the utility is forced to build the private, intermediate mesh network. If the commercial wireless providers could arrive at a pricing model that would place the cost of service to the individual meters at a point that is lower or equal to the mesh option, then the Smart Grid deployments could theoretically be implemented at a much faster pace than when the utilities have to cconstruct their own private wireless systems.

Not having existing broadband networks available could prove to be an obstacle to some Smart Grid deployments. If there are no commercial services available and the cost of placing a private system is such that it drives the total cost of the AMI beyond what is acceptable to the public utility commissions then the Smart Grid implementations in those areas could be delayed until a reasonable cost-effective solution is identified. In one of AEP's jurisdictions this is exactly the case. AEP and the responsible public utility commission have decided to delay making the decision on how the most remote 20% of that AEP operating company's service territory will be deployed since the existing identified solutions are too costly. It was jointly decided that the more populated areas would be completed first to allow time for a suitable solution to be identified for the most rural areas. While the cost of the communications network is normally only a relatively small part of the overall cost of an AMI deployment, it could be the determining factor as to whether or not a viable business case can be made for a Smart Grid deployment in a given geographic area. Deployment of advance Smart Grid technologies will certainly be a challenge in the rural areas of the United States where commercial services are not available and the cost to deploy a private broadband system is costly. AEP has some experience with the modeling of coverage and costing of private broadband solutions at frequencies of 2.5 GHz. The private deployment of broadband solutions at these frequencies to cover large areas of service territory for AMI last mile connectivity would be very costly, beyond what the company could build a viable business case for. Anything the FCC could do to encourage the availability of cost effective commercial broadband services in the rural areas would help mitigate this issue. The FCC could also promote the allocation of dedicated spectrum, preferably below 2 GHz, for critical infrastructure use. This spectrum would be used by utilities to implement private broadband systems where commercial systems are not available.

3. Spectrum

As noted by the Commission in its Public Notice, Smart Grid technologies incorporate a wide variety of private and public network technologies. Starting twenty years ago with licensed Multiple Address System (MAS) channels for substation SCADA, AEP has built a considerable portfolio of private communication systems to support intelligence embedded in the electric grid. While a limited number of applications that use licensed MAS and private land mobile radio (PLMR) channels to transmit low-bandwidth data are in service at AEP today, in recent years the Company has gravitated towards using the unlicensed 902 – 928 MHz Industrial, Scientific, Medical (ISM) band for many Smart Grid deployments. Frequency Hopping Spread Spectrum (FHSS) technology is the predominant 900 MHz modulation scheme in use at AEP today, though Orthogonal Frequency Division Multiplexing (OFDM) radios are also becoming more common in the industry. AEP has used both mesh and point-to-multipoint architectures, depending on the application and facilities (usually tower infrastructure) available for a particular project.

3.1 Licensed Spectrum Issues

While AEP would prefer the interference protection afforded by licensed spectrum, the limited throughput of the relatively narrow channels in the PLMR service is not practical for most modern smart grid applications, given the overhead imposed by the network and application protocols used. Furthermore, unlicensed spectrum has traditionally offered more regulatory flexibility than PLMR channels, making deployment easier and subject to fewer constraints. Other non-PLRM licensed spectrum has been available at auction and on the secondary market, but no compelling utility applications for this spectrum have emerged. In AEP's case, there are several concurrent issues. First, AEP's service territory is very irregular and does not match up well with the various geographic areas used in auctioning spectrum. To date, AEP has declined to participate in spectrum auctions because meeting construction requirements for license areas that fall outside AEP's electric service territory would be difficult to justify and most likely pull AEP into the telecommunications business, an enterprise the Company is not interested in pursuing. Furthermore, the piecemeal spectrum holdings of those organizations which participate in the secondary spectrum markets make it extremely difficult to deploy a system capable operating throughout a single AEP operating company, let alone the entire AEP system. Finally, equipment suitable for the utility operating environment that utilizes auctioned/secondary market spectrum for broadband communications is nearly non-existent. All three of these issues could be alleviated if utilities had a nationwide allocation of spectrum that allowed them to use the same equipment to build smart grid networks anywhere in their service territory. This would allow an ecosystem of solutions to flourish since equipment vendors would need only to build wireless equipment for a common utility band rather than having to supply a number of differing solutions for a market with fractured spectrum allocations.

3.2 Interference Issues with Unlicensed Spectrum

While AEP relies heavily on unlicensed spectrum, it does so with the realization that interference is always a potential problem that could increase the cost of deploying new installations or maintaining existing systems. But given little progress in the way of higher-speed solutions that operate in licensed spectrum, the Company feels it has no choice but to use devices that operate in unlicensed spectrum. Fortunately, the FHSS radios in use today are fairly robust in the face of signals from other users, work remarkably well, and represent a viable solution for the time-being. AEP is hopeful unlicensed technology can stay ahead of the interference problem, but the physical reality is that a given amount of spectrum has a finite information-carrying capacity. The increasing use of wireless technology by users of all sorts will put pressure on all unlicensed bands and AEP is not sure these bands will remain viable for critical applications in the long term.

AEP has coped mainly with two types of interference: direct in-band interference from other spectrum users and an increase in overall noise-floor in metropolitan areas. The first type of interference has occurred chiefly in rural areas where wireless internet service providers have installed 900 MHz last-mile solutions in close proximity to substations and other facilities with which AEP is trying to communicate. Typically, the locations are relatively far from the AEP base station, meaning the local “foreign” transmitter overpowers a weaker signal from the distant AEP base station. In some cases, the interference can be mitigated by careful coordination with the other spectrum user if the other party is willing to cooperate. In other cases mitigation is achieved by adding an additional base station or eliminating the use of wireless altogether.

In addition to direct interference by specific transmitters in the same band, some metropolitan areas of AEP's service territory have seen a higher noise floor, i.e. an overall increase in background noise due to a large number of industrial, commercial, and consumer devices in operation. This increased noise floor decreases the overall signal-to-noise ratio of the signal arriving at the receiver, which by Shannon's limit reduces the distance and/or speed of wireless communication in the affected band. For AEP, this has been primarily of concern with point-to-multipoint solutions which tend to rely on longer line-of-sight paths to achieve connectivity. As a result, AEP has continued to operate radios that operate in the 100 kbps range rather than stepping up to newer technology capable of operating at 1 Mbps and higher. Furthermore, by using mesh technology interference is overcome by using a higher number of much shorter links, increasing signal-to-noise and allowing for robust communication. However, neither of these mitigation approaches is without its problems. As such, AEP no longer finds 900 MHz point-to-multipoint networks suitable for backhaul / aggregation of Smart Grid data. And while 900 MHz mesh networks are suitable for today's relatively modest data requirements in the Smart Grid, increasing needs for throughput may push mesh networks beyond their capabilities as well.

Because of the issues associated with the 900 MHz ISM band, one solution AEP has been looking at includes the 3.65 GHz band for 802.16(e) WiMAX point-to-multipoint systems. While the "lightly-licensed" approach for this band doesn't completely eliminate the interference issues associated with non-exclusive spectrum, the

Company believes it has the potential to provide some relief to the pressure that is slowly building on the 900 MHz band. Of course, the reduction in coverage as a result of going higher in frequency will increase the amount of infrastructure required to serve a given area. Likewise, a move up to 5.2/5.8 GHz is problematic (due to the increased propagation losses) in all but the densest deployments and given AEP's mostly rural service territory, seems to be unrealistic as an option for AEP.

3.3 Adequacy of Spectrum Allocations

While AEP is successfully deploying Smart Grid technology today with the existing mix of licensed and unlicensed allocations, it is important to note that it is still early in the technology development cycle. Utilities have approached Smart Grid deployments rather conservatively, implementing relatively simple applications with modest data needs that could be met by current private and public network technologies. Many of these applications have been driven by a desire to meet basic business needs in a cost effective, secure manner. However, as these applications proliferate, they will enable new ways of doing business and interacting with customers which will in turn drive an increase in data throughput needs. In many situations, these new applications will be driven by outside interests, such as public utility commissions, consumer product developers, and customers themselves, and these may be well outside the control of the utility. AEP is concerned that the needs of advanced Smart Grid applications may explode past the level that can be adequately served by the technologies and spectrum allocations that seem adequate today.

With this in mind, AEP believes a new spectrum allocation below 2 GHz and dedicated to utility use would advance Smart Grid deployment, allowing the technology to evolve more quickly and pull together applications that are deployed in a piecemeal fashion today. If such an allocation allowed for higher power levels than those currently allowed in unlicensed bands, deployment costs for Smart Grid could be significantly reduced, further encouraging the deployment of the Smart Grid.

If a new allocation of dedicated spectrum were to be made available to utilities, AEP fully expects that the increased bandwidth available will encourage new and innovative applications in the Smart Grid space. While today's applications are being adequately met by the piecemeal combination of technologies, a standardized spectrum allocation would encourage the growth of an ecosystem to support Smart Grid tehnologies on a common wireless platform.

4.0 Real-time Data

Use of the phrase "real-time" has different connotations and meaning dependent upon one's point of reference. In the discussions around Smart Grids in the electric industry, real-time typically implies dealing in time increments less than 1-2 seconds with the skew being far less than 1 second in the electrical network monitoring/control functions. Above that "real-time" range are several other time-duration-response windows that range from a few seconds to: few minutes; 15 minutes; an hour; 4 hours; daily; monthly; seasonal.

In the context of what appears to be the focus of this section on energy consumption and pricing data, the general measure of time ends up being a few minutes up to and including seasonal versus less than 1-2 seconds. This interpretation of time scale is used below, and ends up not getting into all the Distribution Automation, Transmission SCADA, and electrical network monitoring/control functions and applications that are automated.

4.1 Customer Access in Smart Meter Deployments

All customers have or will have the opportunity to access energy consumption and pricing data specific to their account. The percentage of customers that will actively access that information by any of the means available is driven by the customer's active selection of a method and still needs to be determined.

4.2 Data Access Methods

Several methods have been implemented and are planned for implementation that are specific to the jurisdictions AEP does business in. Each method also has a specific time response / latency. The table below summarizes the various methods being used or planned to be deployed.

Data Access Method	Data - Time Periods	Data Refresh Rate	Merits / Risks
Energy Consumption Data			
Web Portal	Hourly, daily, weekly, monthly	Daily	• Web-based application • Customer must have access to Internet • Securing customer data
In-Premise-Display	Last meter register read	7.5 – 30 secs for those accessing ESI via meter If using meter company web-portal, and out of band connection to web-portal, then typically daily	• Faster data refresh rate than web portal • Reduced security exposure than web portal • Cost and maint of display device • Small display window and content versus web portal web app opportunity • Display market is slow to mature • Standards are still in flux so early implementations are

Data Access Method	Data - Time Periods	Data Refresh Rate	Merits / Risks
			dependent upon what source of consumption data is used and the available display devices that source will certify for use. • Allowing the customer to acquire whatever display devices to use will create issues, unless industry protocol compliance / certification standards are established and used.
Meter Display	demand, kwh values in time periods dependent upon meter capability and what's programmed to be displayed	depends on what data is displayed, typically in a rolling sequence to the display. Some data may be a few seconds old, others hours or even day old.	• Not all smart meters have this option installed/enabled • Typically only demand • Must go to meter to read • Meter typically has more public view access than in premise displays
Customer voice call to customer service OR optional web-portal enabled application for ad.hoc meter data request	15 min, hourly, daily, weekly	Ad-hoc with ~1-2 minute response depending upon utility / REP / customer relationship and network traffic loading end-to-end	• Faster data refresh than web portal • Customer call-in to utility or REP for the information • Securing customer data
Pricing Data			
Web Site	Depends on jurisdictions current approved tariffs specifics e.g. seasonal, day of week, time of day	Depends on jurisdictions for reporting / posting current approved tariffs	• Web-based application • Customer must have access to Internet • In at least one jurisdiction, the REPs are not required to post their TOU tariffs and the REPs do not post them.
In-Premise-Display	15 min, hourly, TOU, seasonal	• Depends on jurisdictions for reporting / posting current approved tariffs • Typically day ahead hourly for "real-time pricing plans" for large commercial / industrial, with current day hourly • For some jurisdiction REPs expect to push 15 min interval pricing every 15 min.	• Provides current applicable pricing information in ready view of in-premise occupants • Cost and maint of display device • Small display window • Display market is slow to mature • Standards are still in flux so early implementations are dependent upon what source of consumption data is used and the available display devices that source will certify for use.

Data Access Method	Data - Time Periods	Data Refresh Rate	Merits / Risks
			• Allowing the customer to acquire whatever display devices to use will create issues, unless industry protocol compliance / certification standards are established and used.

Table 4.2 - Data Access Methods and Characteristics

A common risk that crosses most of the methods above is security. The general aims that should be addressed with how consumers access data include the following:

- Ownership of identity – adding value to customer information, but not controlling it
- Privacy – keeping individual information as private as possible
- Efficiency – maintaining identity in as few places as possible
- Personalized services – ala-cart services should be available
- Publishing identity and address information
- Authentication for service entitlement
- Paying for goods and services

Risks for this area include the following:

- Integrity, including non-repudiation, of pricing information is critical, since there could be large financial and possibly legal implications
- Availability, including non-repudiation, for pricing signals is critical because of the large financial and possibly legal implications
- Confidentiality is important mostly for the responses that any customer might make to the pricing signals

NIST recently issued a draft report http://csrc.nist.gov/publications/drafts/nistir-7628/draft-nistir-7628.pdf from the Cyber Security Coordination Task Group concerning various potential security and privacy issues with Smart Grids. This report should also be considered along with the other security points listed in this response.

4.3 Use of Data by Third Parties

Before addressing the question of how a third party application developer or device maker should use the data, the ownership of that data must be established. In at least one competitive electric utility jurisdiction, retail electric providers (REPs) are arguing that the data is their intellectual property, does not belong to the customer. Furthermore, they do not want data from time periods when they were the customer's REP of record shared with any REP that the customer may switch to in the future. Also in that same jurisdiction, the REPs are not required to post their TOU tariffs and most do not. This precludes third-party application developer from even accessing the data.

Even if third party application developers and device makers are granted access to this data, they should never have access to real-time consumption data or pricing data without scrubbing it first to ensure that no customer identifiable data is available to unauthorized parties.

Privacy and security requirements should not stifle innovation if implemented correctly, which means that privacy and security needs were engineered and architected at the beginning of a product/systems lifecycle. It costs more to implement privacy and security requirements after the system is implemented and is actually less effective than it would be if these requirements were integrated from the beginning of the lifecycle.

4.4 Use of Data to Reduce Load & Consumption

The value of providing real-time pricing and consumption data is a topic still being explored by AEP through its pilots and early deployments of AMI tehnology. Earlier experiences in RTP for large commercial and industrial customers has (naturally) shown that if the pricing differential is not enough to incent customers to participate, they will not so. However, more research is needed to understand what factors are involved in increasing customer participation and how much energy such programs can potentially save.

4.5 More Granular Consumption Data

Going to lower increments of RTP requires that the critical pricing from other entities providing prices into that customer RTP must also market at that more granular level. Some organizations, like Regional Transmission Operators (RTOs) may not be able to accommodate such granularity. This also requires that the interval reading data is also taken down to that same level, which increases data traffic and storage requirements of that data. It has yet to be determined which customer class(es) would take advantage of and experience the benefits of increased granularity.

One jurisdiction, claims the benefit to more granular data is on the wholesale side where wholesale settlement is made on 15 minute intervals. By having the same granularity on the retail side, the thought is the REPs can pass on the savings they get from the wholesale transactions to the retail customers. Today the REPs purchase wholesale power based on time of day, but sell it to the consumer base on "one simple price".

4.6 Consumer Energy Management Device and Application Choice

As mentioned in the table above for in-premise-displays, the choice of devices and applications is and will continue to be driven by the sources of the customer’s consumption data. e.g. web portal, ZigBee HAN, or other in-home interface protocol standard to the AMI meter. Provided that the energy management devices and applications that the customer finds in the market are compliant to those protocols that the energy provider, the main focus should be on having adequate protection and/or restrictions around the parties who have access to that information across that extended computing and communications environment.

There are existing security concerns that still need to be addressed. These concerns are similar to those addressed through "Identity and Access Management" (IAM). Included are:

- Names as identity/device – how to prove who/what you are
- Authorization identity
- Federation of identity
- Credentials and protocols
- Authentication/Authorization identifier
- Authority of source
- Trust and trust models

5.0 Home Area Networks

The Home Area Network (HAN) is arguably one of the greatest areas of interest related to Smart Grids, since it will be the network touch point between the utility and consumer smart energy applications. However, the utility-to-HAN interface is currently one of the least defined areas of the Smart Grid and in the greatest flux as new technical specifications that determine how the customer receives and processes energy information are now being defined. So while a number of conceptual models for home energy applications have emerged over the past several years, the protocols that enable those models are only now coming forth.

5.1 HAN Devices

Since the technical specifications for defining how energy applications interact with the utility AMI network were sorely lacking, AEP and a number of other electric utilities joined with consumer product vendors and state regulators to create a specification referred to as the *OpenHAN Task Force 2008 Home Area Network System Requirement Specification.* This document listed eight logical HAN devices:

- Energy Services Interface (ESI)
- Programmable Communicating Thermostat (PCT)
- Display or In-Home Display (IHD)
- Energy Management System (EMS)
- Load Control Device
- Electric Meter
- Non-Electric Meter
- Smart Appliance

The ESI represents utility's energy portal which resides in an AMI meter or in some other stand-alone device. The EMS is a complex platform to interact with the other devices listed above as well as future equipment (like plug-in electric vehicles) not yet defined in the 2008 HAN specification. This provides a flexible platform for implementing energy consumer applications while providing some to utility networks from the changes that will be occurring as a result of the continuing evolution of the consumer electronics space.

The most prevalent meter HAN technology available today is ZigBee, an IEEE 802.15.4-based wireless mesh technology. Included in most utility deployments is a ZigBee-specific protocol known as the Smart Energy Profile (SEP), which describes a primitive byte-oriented command-set for maintaining time of day and exchanging simple metering, pricing, text and load control information between the utility and the consumer(s) devices. As such, data passed between these devices is quite minimal and rich data sets and behavior models are generally not available today.

Because the functionality of the existing SEP is so limited and Zigbee-Specific, a new version is under development and will be based on the IEC Common Information Model (CIM) for Smart Grids. Furthermore, due to some of ZigBee's limitations, the HAN technology space may evolve to include a number of other wireless and wired (chiefly in-premise broadband over power line) technologies. Because of this evolution, it only follows that the amount of data exchanged over the HAN will continue to increase over time.

5.2 Internet Connectivity to the HAN

In addition to building a home energy network, the consumer will have the option to also take advantage "off-premise" energy applications. These applications include real-time and critical peak pricing programs, distributed energy resource integration for PEVs and dispatchable energy storage/generation devices, home telematics for remotely controlling or configuring devices in the home, and social energy networking applications like Microsoft Hohm and Google PowerMeter. These applications (which may or may not include the participation of the consumer's serving utility) are expected to communicate with the consumer's EMS or in-home devices over the Internet.

While the utility Smart Grid networks that are being deployed for AMI and other applications may also play a role in these applications, it is important to note that the utility networks are being deployed to meet specific business requirements for the utility (such as cost, security, and basic functionality) and not as general purpose communications networks. As such, AEP believes that the above energy applications may be better suited to run over a broadband internet connection as their requirements are unknown today (but certainly have the potential to overwhelm the available AMI technology.)